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(54) Title: COATED GROOVING OR PARTING INSERT

(57) Abstract: The present invention relates to a coated cutting tool (cemented carbide insert) useful for grooving or particularly parting of steel components such as steel or stainless steel tubes and bars. The insert is characterised by WC-Co-based cemented carbide substrate having a highly W-alloyed Co-binder phase and a hard and wear resistant coating including a multilayered structure of sublayers of the composition (Ti_xAl_{1-x})N with repeated variation of the Ti/Al ratio.

Coated grooving or parting insert

The present invention relates to a coated cutting tool (cemented carbide insert) useful for grooving or particularly parting of steel components such as bars or tubes of stainless steels of different composition and microstructure but also for of non-stainless steels such as low carbon steels and low and medium alloyed steels.

When machining low and medium alloyed steels and stainless steels with cemented carbide tools the cutting edge is worn according to different wear mechanisms, such as chemical wear, abrasive wear, adhesive wear and by edge chipping. In bad conditions problems with bulk and edge line breakages occur commonly. Furthermore, different cutting conditions such as cutting speed, cutting feed rate and also external conditions such as dry or wet machining, heavy vibrations of the work piece etc., require a plurality of different properties of the cutting edge.

So far it has been very difficult to improve all tool properties simultaneously. Commercial cemented carbide grades have therefore been optimized with respect to one or few of these wear types and hence to specific application areas.

WO 97/20083 discloses a coated cutting insert particularly useful for dry and wet machining in low and medium alloyed steels, stainless steels, with or without raw surface zones under severe conditions such as vibrations, long overhang and recutting of chips. The insert is characterized by WC-Co cemented carbide with a low content of cubic carbides and a rather low W-alloyed binder phase and a coating including an innermost layer of $\text{TiC}_x\text{N}_y\text{O}_z$ with columnar grains and a top layer of TiN and an inner layer of $\text{K-Al}_2\text{O}_3$.

Swedish patent application SE 9901149-6 discloses a coated cutting insert particularly useful at high cutting speeds, of stainless steels of different composition and microstructure, but also for the milling of non-stainless steels such as low carbon steels and low and medium alloyed steels. The coated WC-Co based cemented carbide insert is characterized by a specific composition range of WC/Co without any addition of cubic carbides, by a low W-alloyed Co binder and by a narrow range defined average WC grainsize, and a hard and wear resistant coating including a multilayered structure of sublayers of the composition $(Ti_xAl_{1-x})N$ with repeated variation of the Ti/Al ratio.

It has now surprisingly been found that a combination of a slightly modified cemented carbide substrate described in the above mentioned WO 97/20083 and the coating described in the above mentioned SE 9901149-6 results excellent cutting performance in grooving or, in particular, parting of steel or stainless steel.

In Fig. 1 is shown a micrograph in 1200X magnification of a polished cross section of a coated insert according to the present invention:

- A - cemented carbide body
- B - innermost TiN layer
- C - layer of several TiAlN sublayers
- D - layer of TiAlN
- E - outermost TiN layer

According to the present invention there is provided a coated cutting tool insert for toughness demanding grooving and parting of stainless steels comprising a WC-Co based cemented carbide body with a composition of 11.5-13.6 wt% Co, preferably 12.0-13.0 wt% Co, most preferably 12.3-12.9 wt% Co, 0.2-1.8 wt%

cubic carbides, preferably 0.4-1.8 wt% cubic carbides, most preferably 0.5-1.7 wt% cubic carbides of the metals Ta, Nb and Ti and balance WC. The cemented carbide may also contain other carbides from elements from group IVb, Vb or VIb of the periodic table. The content of Ti is preferably on a level corresponding to a technical impurity. The average grain size of the WC is about 1.1-2.1 μm , preferably about 1.4 μm .

The cobalt binder phase is rather low alloyed with W. The content of W in the binder phase can be expressed as the CW-ratio:

$$\text{CW-ratio} = M_s / (\text{wt\% Co} \cdot 0.0161),$$

where M_s is the saturation magnetization of the cemented carbide body in kA/m and wt% Co is the weight percentage of Co in the cemented carbide. The CW-value is a function of the W content in the Co binder phase. A high CW-value corresponds to a low W-content in the binder phase.

It has now been found according to the present invention that improved cutting performance is achieved if the cemented carbide body has a CW-ratio of 0.80-0.92, preferably 0.82-0.91, and most preferably 0.85-0.90. The cemented carbide may contain small amounts, <1 volume %, of η -phase (M_6C), without any detrimental effect. From the CW-value it follows that no free graphite is allowed in the cemented carbide body according to the present invention.

The hard and wear resistant refractory coating deposited on the cemented carbide substrate according to the present invention comprises:

- a first (innermost) thin 0.1-0.5 μm bonding layer of TiN
- a second layer comprising a multilayered structure of sublayers of the composition $(\text{Ti}_x\text{Al}_{1-x})\text{N}$ in which x varies repeatedly between the two ranges

0.45<x<0.55 and 0.70<x<0.80. The first sublayer of (Ti_xAl_{1-x})N adjacent to the TiN bonding layer having an x-value of 0.45<x<0.55, the second sublayer of (Ti_xAl_{1-x})N having an x-value of 0.70<x<0.80 and the
5 third sublayer having x of 0.45<x<0.55 and so forth repeated until 12-25 sublayers, preferably 22-24 sublayers, are being built up. The thickness of this second layer comprising a multilayered structure of sublayers constitutes 75-95% of the total coating
10 thickness. The individual sublayers of (Ti_xAl_{1-x})N are essentially of the same thickness but their thickness may also vary in a regular or irregular way and said sublayer thickness is 0.05-0.2 μm.

- a third 0.1-0.5 μm layer of (Ti_xAl_{1-x})N having an
15 x-value of 0.45<x<0.55.

- a fourth (outermost) thin 0.1-0.2 μm layer of TiN.

The total thickness of the coating is 1-8 μm, preferably 2-5 μm. The layer thickness, the sublayer
20 thickness and the coating thickness quoted above refers to measurements made close to the cutting edge, i. e. the functional part of the cutting tool.

The present invention also relates to a method of making a coated cutting tool insert consisting of a
25 cemented carbide body with a composition of 11.5-13.6 wt% Co, preferably 12.0-13.0 wt% Co, most preferably 12.3-12.9 wt% Co, 0.2-1.8 wt% cubic carbides, preferably 0.4-1.8 wt% cubic carbides, most preferably 0.5-1.7 wt% cubic carbides of the metals Ta, Nb and Ti and balance
30 WC. The cemented carbide may also contain other carbides from elements from group IVb, Vb or VIb of the periodic table. The content of Ti is preferably on a level corresponding to a technical impurity. The average grain size of the WC is about 1.1-2.1 μm, preferably about 1.4 μm.

The hard and wear resistant refractory coating is deposited onto the cemented carbide substrate by applying conventional PVD (Physical Vapor Deposition) or CVD (Chemical Vapor Deposition) methods and according to the present invention said coating comprises:

- a first (innermost) thin 0.1-0.5 μm bonding layer of TiN
- a second layer comprising a multilayered structure of sublayers of the composition $(\text{Ti}_x\text{Al}_{1-x})\text{N}$ in which x varies repeatedly between the two ranges 0.45< x <0.55 and 0.70< x <0.80. The first sublayer of $(\text{Ti}_x\text{Al}_{1-x})\text{N}$ adjacent to the TiN bonding layer having an x -value of 0.45< x <0.55, the second sublayer of $(\text{Ti}_x\text{Al}_{1-x})\text{N}$ having an x -value of 0.70< x <0.80 and the third sublayer having x of 0.45< x <0.55 and so forth repeated until 12-25 sublayers, preferably 22-24 sublayers, are being built up. The thickness of this second layer comprising a multilayered structure of sublayers constitutes 75-95% of the total coating thickness. The individual sublayers of $(\text{Ti}_x\text{Al}_{1-x})\text{N}$ are essentially of the same thickness but their thickness may also vary in a regular or irregular way and said sublayer thickness is 0.05-0.2 μm .
- a third thin 0.1-0.5 μm layer of $(\text{Ti}_x\text{Al}_{1-x})\text{N}$ having an x -value of 0.45< x <0.55.
- a fourth (outermost) 0.1-0.2 μm layer of TiN.

Example 1

A. Cemented carbide parting tool insert in accordance with the invention with the composition 12.6 wt-% Co, 1.25 wt-% TaC, 0.30 wt-% NbC and balance WC with 1.4 μm grain size and with a binder phase alloyed with W corresponding to a CW-ratio of 0.91 were coated with a 4 μm thick coating by applying conventional PVD cathodic arc technique. The coating consisted of a first (innermost) 0.2 μm layer of TiN followed by a 3.2 μm

thick second layer comprising 23 alternating sublayers of $(\text{Ti}_x\text{Al}_{1-x})\text{N}$, where x alternatively varied between 0.55 and 0.75, and a third $0.2 \mu\text{m}$ $(\text{Ti}_x\text{Al}_{1-x})\text{N}$, where $x = 0.55$, and, finally, an outermost $0.4 \mu\text{m}$ layer of TiN .

5 B. A cemented carbide parting tool insert with the composition of 8.0 wt-% Co, no cubic carbides, balance WC and a CW-ratio of 0.94. The insert was coated with an innermost $0.5 \mu\text{m}$ equiaxed TiCN -layer A $1.5 \mu\text{m}$ TiN layer was deposited, during the same cycle, on top of the
10 TiCN -layer. No post treatment was applied.

C. A competitive cemented carbide parting tool insert in style similar to previous mention inserts from an external leading cemented carbide producer was selected for comparison. The cemented carbide had a
15 composition of 12.5 wt-% Co, 0.1 wt-% TiC , 1.8 wt-% TaC , 0.2 wt-% NbC , balance WC and a CW-ratio of 0.87. The insert had a coating consisting of $1.4 \mu\text{m}$ TiN and, outermost, $1.4 \mu\text{m}$ TiCN . Examination in light optical
20 microscope revealed no edge treatment subsequent to coating.

Inserts A, B and C from above were tested in a parting off to centre in stainless steel SS2321 with OD 26 mm. The cutting speed was varied from 86 to 0 m/min
25 with feed 0,05 mm/r. The wear mechanism was uneven flank wear and chipping.

	Insert	Number of components
	A (invention)	50
30	B (outside invention)	13
	C (external grade)	41

Example 2

Insert A and B were tested at an end user's machine
35 shop in a parting of a stainless steel component (AISI

316 OD 42 mm) with cutting speed varying from 110 to 0 m/min and with feed varying 0,08-0,03 mm/r (low feed rate close to centre of bar). The wear mechanism was fracture in cutting zone.

5

Insert	Number of components
A (invention)	201
B (outside invention)	224

10 Example 3

Insert A and B were tested at an end users machine shop in a parting of a steel component (SS2172 OD 47 mm) with rotating speed 1800 rpm and with feed 0,1 mm/r. The wear mechanism was flank wear and flaking.

15

Insert	Number of components
A (invention)	163
B (outside invention)	50

20 Example 4

Insert A and C were tested at an end user's machine shop in a parting of a stainless steel component (AISI 316 OD 31 mm) with cutting speed varying from 60 to 0 m/min and with feed varying 0,06-0,03 mm/r (low feed rate close to the centre of the bar). The wear mechanism was flank wear and chipping.

25

Insert	Number of components
A (invention)	182
C (external grade)	43

30

Claims

1. A cutting tool insert particularly for parting of steel and stainless steel comprising a cemented carbide body and a coating characterized in that said cemented carbide body consists of WC with an average grain size of about $1.4\text{ }\mu\text{m}$, 12-13 wt-% Co and 0.4-1.8 wt-% TaC+NbC, and a low W-alloyed binder phase with a CW-ratio of 0.82-0.91 and in that said coating comprises
- 10 - a first (innermost) $0.1\text{-}0.5\text{ }\mu\text{m}$ layer of TiN
 - a second layer comprising a multilayered structure of $0.05\text{-}0.2\text{ }\mu\text{m}$ thick sublayers of the composition $(\text{Ti}_x\text{Al}_{1-x})\text{N}$ in which x varies repeatedly between the two ranges $0.45 < x < 0.55$ and $0.70 < x < 0.80$, the
 - 15 first sublayer of $(\text{Ti}_x\text{Al}_{1-x})\text{N}$ adjacent to the TiN bonding layer having an x-value of $0.45 < x < 0.55$, the second sublayer of $(\text{Ti}_x\text{Al}_{1-x})\text{N}$ having an x-value of $0.70 < x < 0.80$ and the third sublayer having x of $0.45 < x < 0.55$ and so forth repeated until 12-25 sublayers are being built up.
 - 20 - a third $0.1\text{-}0.5\text{ }\mu\text{m}$ thick layer of $(\text{Ti}_x\text{Al}_{1-x})\text{N}$, where x is $0.45 < x < 0.55$
 - a fourth (outermost) $0.1\text{-}0.2\text{ }\mu\text{m}$ layer of TiN where the total coating thickness is $1\text{-}8\text{ }\mu\text{m}$ and where the thickness of the second layer constitutes 75-
 - 25 95% of the total coating thickness.
2. Cutting insert according to claim 1 characterized in that the cemented carbide has the composition 12.3-12.9 wt-% Co and 0.5-1.7 wt% TaC+NbC.
- 30 3. Cutting insert according to any of the preceding claims characterized in that the cemented carbide body is free from graphite.
4. Method based on known PVD or CVD techniques of making a coated cemented carbide cutting tool insert
- 35 comprising a WC-Co based cemented carbide body and a

hard and wear resistant coating,
characterized in depositing on a cemented
carbide body comprising a WC with an average grain size
of about 1.4 μm , 12-13 wt-% Co and 0.4-1.8 wt-% TaC+NbC,
5 and a low W-alloyed binder phase with a CW-ratio of
0.82-0.91, a coating comprising

- a first (innermost) 0.1-0.5 μm layer of TiN
- a second layer comprising a multilayered
structure of 0.05-0.2 μm thick sublayers of the
10 composition $(\text{Ti}_x\text{Al}_{1-x})\text{N}$ in which x varies repeatedly
between the two ranges $0.45 < x < 0.55$ and $0.70 < x < 0.80$, the
first sublayer of $(\text{Ti}_x\text{Al}_{1-x})\text{N}$ adjacent to the TiN bonding
layer having an x-value of $0.45 < x < 0.55$, the second
sublayer of $(\text{Ti}_x\text{Al}_{1-x})\text{N}$ having an x-value of $0.70 < x < 0.80$
15 and the third sublayer having x in the range $0.45 < x < 0.55$
and so forth repeated until 12-25 sublayers are being
built up.

- a third 0.1-0.5 μm thick layer of $(\text{Ti}_x\text{Al}_{1-x})\text{N}$,
where x is $0.45 < x < 0.55$
- 20 - a fourth (outermost) 0.1-0.2 μm layer of TiN
making the total coating thickness close to the
cutting edge vary in the range of 1-8 μm and where the
thickness of the second layer constitutes 75-95% of the
total coating thickness.

25 6. Method according to the previous claim
characterized in that said cemented carbide
body comprises a WC-Co composition of WC with an average
grain size of about 1.4 μm , 12-13 wt-% Co and 0.4-1.8
wt-% TaC+NbC, and a low W-alloyed binder phase with a
30 CW-ratio of 0.82-0.91.

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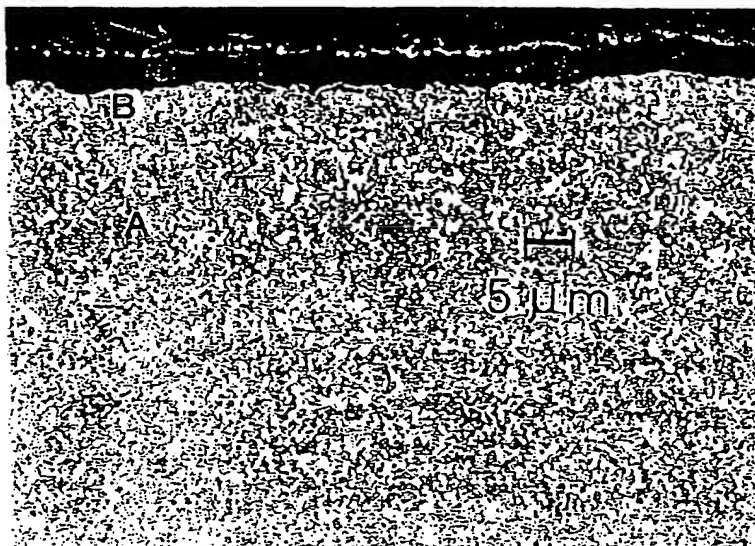


Fig. 1

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 00/01677

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C22C 29/08, C23C 16/30, C23C 16/40, C22C 28/00, B23B 27/14
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C23C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9720083 A1 (SANDVIK AB), 5 June 1997 (05.06.97) --	1-5
A	EP 0701982 A1 (SUMITOMO ELECTRIC INDUSTRIES, LIMITED), 20 March 1996 (20.03.96) --	1-5
A	Derwent's abstract, No 1999-520900, week 199944, ABSTRACT OF JP, 11222665 (NACHI FUJIKOSHI CORP), 17 August 1999 (17.08.99) --	1-5
E,A	EP 1038989 A2 (SANDVIK AKTIEBOLAG), 27 Sept 2000 (27.09.00) -- -----	1-5

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SE 00/01677

Patent document cited in search report				Publication date		Patent family member(s)	Publication date
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